

Supplementary Material

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Table i. Patient characteristics by study group.

Parameter	Control group	Overall	Acetabular pathomorphologies					Femoral pathomorphologies						
			Anteversión	Retroversion	DDH	Overcover	Severe overcover	Perthes	Cam-type FAI	Mixed-type FAI	Varus	Valgus	High femoral torsion	Low femoral torsion
Hips, n	20	388	7	66	63	31	36	10	126	116	52	46	106	91
Mean age, yrs (SD; range)	54 (9; 37 to 66)	26 (2; 23 to 29)	24 (4; 18 to 29)	27 (10; 14 to 59)	29 (9; 17 to 50)	28 (10; 15 to 47)	39 (11; 17 to 60)	32 (13; 19 to 56)	34 (12; 16 to 65)	31 (11; 14 to 59)	34 (12; 14 to 59)	28 (11; 15 to 58)	30 (11; 15 to 59)	32 (11; 16 to 65)
Left side, n (%)	10 (50)	177 (42)	2 (25)	27 (42)	22 (34)	18 (58)	16 (44)	3 (30)	56 (44)	60 (52)	22 (42)	20 (43)	54 (50)	44 (48)
Male sex, n (%)	14 (70)	193 (50)	0 (0)	35 (54)	17 (27)	9 (29)	12 (33)	8 (80)	78 (62)	67 (58)	36 (69)	12 (26)	30 (28)	56 (62)
Mean height, cm (SD; range)	172 (9; 157 to 186)	172 (8; 154 to 197)	165 (10; 155 to 176)	171 (7; 157 to 181)	168 (7; 155 to 183)	171 (9; 154 to 191)	170 (9; 156-185)	175 (3; 170 to 178)	174 (9; 158 to 197)	172 (8; 154 to 191)	174 (8; 160 to 187)	170 (8; 157 to 183)	170 (8; 156 to 190)	173 (8; 155 to 197)
Mean weight, kg (SD; range)	79 (15; 46 to 108)	73 (14; 44 to 134)	64 (12; 52 to 80)	72 (14; 44 to 100)	71 (14; 50 to 103)	71 (19; 46 to 115)	76 (12; 49 to 94)	69 (10; 61 to 80)	74 (14; 44 to 134)	72 (12; 46 to 98)	76 (9; 60 to 92)	71 (14; 50 to 103)	69 (13; 46 to 103)	76 (12; 78 to 102)
Mean BMI, kg/m ² (SD; range)	26 (4; 19 to 31)	25 (4; 16 to 40)	23 (2; 21 to 26)	24 (5; 16 to 33)	25 (4; 18 to 37)	24 (6; 18 to 40)	27 (4; 20 to 35)	23 (3; 21 to 26)	24 (4; 17 to 40)	24 (4; 16 to 35)	25 (3; 20 to 32)	25 (4; 18 to 35)	24 (4; 16 to 35)	25 (3; 19 to 33)
Surgical intervention, n (%)														
None	20 (100)	177 (46)	4 (50)	31 (48)	24 (38)	19 (61)	15 (42)	8 (80)	66 (52)	48 (41)	29 (56)	25 (54)	51 (47)	49 (54)

SHD	0 (0)	108 (28)	1 (13)	17 (26)	4 (6)	10 (32)	16 (44)	2 (20)	31 (25)	45 (39)	13 (25)	15 (31)	33 (31)	14 (15)
PAO	0 (0)	41 (11)	2 (25)	11 (17)	30 (47)	0 (0)	0 (0)	0 (0)	0 (0)	7 (6)	2 (4)	9 (19)	14 (13)	11 (12)
HAS	0 (0)	45 (12)	1 (13)	5 (8)	4 (6)	2 (7)	2 (6)	0 (0)	25 (20)	13 (11)	6 (12)	1 (2)	5 (5)	15 (16)
THA	0 (0)	11 (3)	0 (0)	1 (2)	2 (3)	0 (0)	3 (8)	0 (0)	4 (3)	3 (3)	2 (4)	0 (0)	2 (2)	2 (2)

DDH, developmental dysplasia of the hip; FAI, femoroacetabular impingement; HAS, hip arthroscopy; PAO, periacetabular osteotomy; SHD, surgical hip dislocation; SD, standard deviation; THA, total hip arthroplasty.

Table ii. Radiological parameters of the study groups.

Mean parameter (SD; range)	Control group	Acetabular pathomorphologies					Femoral pathomorphologies						
		Anteversio	Retroversio	DDH	Overcover	Severe overcover	Perthes	Cam-type FAI	Mixed-type FAI	Varus	Valgus	High femoral torsion	Low femoral torsion
Hips, n (patients)	20 (20)	7 (7)	66 (60)	63 (59)	31 (27)	36 (34)	10 (10)	126 (118)	116 (106)	52 (46)	46 (40)	106 (98)	91 (84)
LCEA, °	33 (4; 25 to 39)	28 (4; 23 to 34)	35 (7; 21 to 51)	17 (5; 5 to 25)	35 (2; 32 to 39)	45 (5; 36 to 63)	17 (12; 3 to 42)	28 (3; 20 to 35)	37 (6; 23 to 63)	33 (9; 11 to 63)	27 (10; 9 to 44)	28 (10; 3 to 52)	30 (8; 13 to 50)
Sharp angle, °	37 (3; 32 to 42)	40 (3; 37 to 46)	27 (3; 28 to 42)	42 (4; 33 to 52)	38 (3; 30 to 46)	34 (8; -9 to 42)	41 (6; 29 to 48)	38 (3; 31 to 46)	36 (3; 27 to 44)	36 (7; -9 to 45)	40 (4; 31 to 52)	40; 4); 29 to 52)	38 (4; 28 to 46)
Acetabular index, %	3 (5; -6 to 9)	3 (5; -6 to 12)	0 (5; -14 to 15)	12 (6; -4 to 28)	-1 (5; -13 to 9)	-6 (5; -14 to 2)	14 (11; -9 to 34)	5 (5; -9 to 21)	-1 (55; -12 to 17)	3 (7; -12 to 21)	5 (9; -12 to 28)	5 (9; -13 to 34)	4 (7; -12 to 25)
Extrusion index, %	18 (4; 11 to 26)	24 (5; 18 to 34)	16 (6; 1 to 28)	32 (6; 14 to 44)	15 (4; 10 to 26)	7 (5; -1 to 22)	33 (11; 11 to 48)	23 (4; 12 to 36)	15 (5; -1 to 29)	18 (9; 1 to 39)	23 (8; 8 to 41)	23 (10; 1 to 49)	20 (8; -1 to 36)
Retroversion index, %	20 (22; 0 to 70)	0 (0; 0 to 0)	44 (17; 21 to 100)	7 (9; 0 to 37)	13 (11; 0 to 29)	8 (10; 0 to 28)	14 (19; 0 to 51)	9 (10; 0 to 45)	23 (21; 0 to 100)	18 (20; 0 to 81)	13 (15; 0 to 47)	12 (16; 0 to 100)	15 (18; 0 to 100)
CCD angle, °	134 (5; 124 to 140)	131 (8; 117 to 140)	131 (6; 116 to 146)	135 (7; 115 to 154)	133 (8; 117 to 161)	131 (7; 119 to 153)	124 (5; 116 to 134)	130 (6; 107 to 148)	130 (7; 116 to 150)	122 (3; 107 to 128)	144 (4; 140 to 161)	134 (8; 116 to 161)	130 (7; 107 to 150)
Alpha angle, °	63 (7; 45 to 75)	57 (3; 53 to 62)	57 (11; 37 to 87)	58 (13; 34 to 105)	47 (7; 33 to 65)	55 (13; 38 to 85)	84 (30; 45 to 143)	66 (9; 51 to 95)	64 (8; 50 to 91)	64 (14; 33 to 105)	55 (13; 34 to 91)	60 (16; 34 to 143)	59 (12; 33 to 95)
Femoral torsion, °	20 (5; 10 to 28)	22 (18; 4 to 58)	16 (11; -3 to 48)	25 (16; -9 to 84)	17 (15; -16 to 58)	20 (13; -12 to 47)	37 (10; 18 to 57)	16 (10; -15 to 55)	17 (11; -13 to 46)	14 (10; -8 to 35)	27 (16; -16 to 58)	35 (9; 25 to 84)	3 (6; -16 to 10)
Acetabular version, °	17 (3; 10 to 25)	27 (7; 15 to 38)	13 (5; -1 to 26)	23 (7; 5 to 38)	20 (6; 5 to 29)	20 (8; 6 to 35)	17 (5; 9 to 29)	19 (6; 7 to 33)	16 (7; -1 to 33)	16 (7; -1 to 33)	21 (7; 1 to 36)	20 (6; 5 to 36)	17 (7; 5 to 38)
Mc Kibbin.-Index, °	37 (7; 21 to 47)	49 (16; 30 to 80)	29 (13; 7 to 72)	48 (19; 8 to 110)	37 (18; 2 to 80)	39 (15; 4 to 71)	54 (8; 46 to 73)	35 (13; 5 to 83)	33 (14; -5 to 77)	30 (13; 5 to 54)	48 (19; 9 to 83)	5 (12; 35 to 110)	20 (9; -5 to 42)
Anterior coverage, %	34 (10; 21 to 56)	11 (3; 6 to 13)	32 (9; 7 to 55)	16 (6; 3 to 26)	27 (8; 6 to 48)	34 (9; 21 to 58)	21 (14; 5 to 54)	23 (6; 10 to 39)	30 (9; 7 to 55)	28 (10; 6 to 58)	22 (9; 4 to 54)	23 (10; 3 to 56)	26 (8; 10 to 55)
Posterior coverage, %	49 (8; 32 to 63)	55 (6; 49 to 62)	38 (7; 19 to 56)	37 (8; 18 to 60)	47 (7; 35 to 62)	55 (11; 31 to 73)	28 (7; 11 to 35)	42 (7; 22 to 63)	44 (9; 19 to 70)	41 (10; 25 to 70)	42 (10; 18 to 62)	42 (10; 11 to 73)	42 (8; 19 to 68)
Total coverage, %	82 (8; 62 to 49)	71 (19; 28 to 85)	81 (11; 31 to 100)	67 (8; 41 to 88)	83 (11; 40 to 94)	89 (8; 57 to 100)	63 (13; 43 to 82)	75 (12; 24 to 92)	83 (10; 31 to 100)	79 (11; 42 to 95)	76 (11; 40 to 95)	76 (12; 14 to 97)	78 (12; 28 to 97)

CCD, centrum-collum-diaphyseal; DDH, developmental dysplasia of the hip; FAI, femoroacetabular impingement; LCEA, lateral centre-edge angle; SD, standard deviation.

Table iii. Literature table comparing the reported influence of demographic factors on pelvic tilt.

Study	Patients, n	Age (yrs), mean (SD) or range	Demographic factor			Measurement method
			Age	Sex	BMI	
Current study	388	26 (2)	No difference	No difference	No difference	Computer-assisted radiograph-based APP (supine)
Nishiwaki et al 2018 ¹	355	67 (11)	Less APP-PT with higher age	N/A	N/A	CT-based APP (supine)
Zahn et al 2016 ²	138	18 (86)	No difference	No difference	N/A	CT-based APP (supine)
Medina KcKeon et al 2009 ³	118	20.6 (2.3)	N/A	Less APP-PT in women	N/A	Goniometric (standing)
Tohtz et al 2010 ⁴	336	56.9 (15.8)	No difference	No difference	N/A	CT-based APP (supine)
Tannast et al 2005 ⁵	20	65.1 (8.1)	N/A	No difference	N/A	CT-based APP (supine)
Shareghi et al 2021 ⁶	106	59 (30 to 80)	Posterior PT with increased age	No difference	N/A	Motion of tantalum markers in relation to a calibration cage

APP, anterior pelvic plane; N/A not applicable; PT, pelvic tilt; SD, standard deviation.

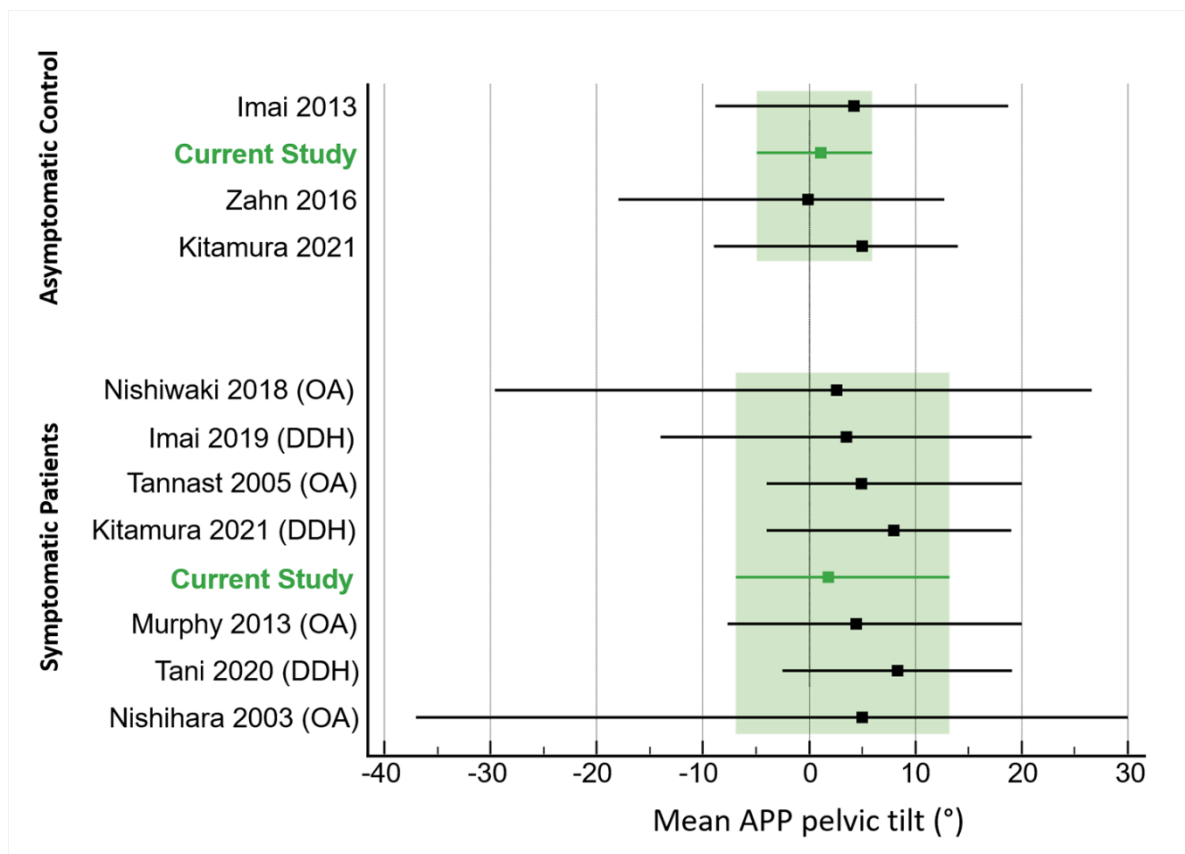


Fig a. A forest plot showing the mean anterior pelvic plane pelvic tilt (APP-PT) values (hedges) reported in the literature compared with those into the current study.^{1,2,7-12} Hedges represent the mean value and solid lines the range of APP-PT values which were reported. DDH, developmental dysplasia of the hip; OA, osteoarthritis.

References

1. **Nishiwaki T, Hata R, Oya A, Nakamura M, Matsumoto M, Kanaji A.** Pelvic tilt displacement before and after artificial hip joint replacement surgery. *J Arthroplasty* 2018;33(3):925–930.
2. **Zahn R, Grotjohann S, Ramm H, Zachow S, Putzier M, Perka C, et al.** Pelvic tilt compensates for increased acetabular anteversion. *Int Orthop* 2016;40(8):1571–1575.
3. **Medina McKeon J, Hertel J.** Sex differences and representative values for 6 lower extremity alignment measures. *J Athl Train* 2009;44(3):249–255.
4. **Tohtz S, Sassy D, Matziolis G, Preininger B, Perka C, Hasart O.** CT evaluation of native acetabular orientation and localization: sex-specific data comparison on 336 hip joints. *Technol Health Care* 2010;18(2):129–136.
5. **Tannast M, Langlotz F, Kubiak-Langer M, Langlotz U, Siebenrock K-A.** Accuracy and potential pitfalls of fluoroscopy-guided acetabular cup placement. *Comput Aided Surg* 2005;10(5–6):329–336.
6. **Shareghi B, Mohaddes M, Kärrholm J.** Pelvic tilt between supine and standing after total hip arthroplasty an RSA up to seven years after the operation. *J Orthop Res* 2021;39(1):121–129.
7. **Imai N, Ito T, Takahashi Y, Horigome Y, et al.** In-vivo relationship between the clinical epicondylar axis and the anterior pelvic plane in normal subjects. *JBiSE* 2013;06(09):863–868.
8. **Kitamura K, Fujii M, Ikemura S, Hamai S, Motomura G, Nakashima Y.** Does patient-specific functional pelvic tilt affect joint contact pressure in hip dysplasia? A finite-element analysis study. *Clin Orthop Relat Res* 2021;479(8):1712–1724.
9. **Imai N, Suzuki H, Nozaki A, Hirano Y, Endo N.** Correlation of tilt of the anterior pelvic plane angle with anatomical pelvic tilt and morphological configuration of the acetabulum in patients with developmental dysplasia of the hip: a cross-sectional study. *J Orthop Surg Res* 2019;14(1):323.
10. **Tani T, Takao M, Uemura K, et al.** Posterior pelvic tilt from supine to standing in patients with symptomatic developmental dysplasia of the hip. *J Orthop Res* 2020;38(3):578–587.
11. **Murphy W, Klingenstein G, Murphy S, Zheng G.** Pelvic tilt is minimally changed by total hip arthroplasty. *Clin Orthop Relat Res* 2013;471(2):417–421.
12. **Tannast M, Langlotz U, Siebenrock K-A, Wiese M, Bernsmann K, Langlotz F.** Anatomic referencing of cup orientation in total hip arthroplasty. *Clin Orthop Relat Res* 2005;(436):144–150.